

Transport sustainability – a bibliometric, systematic methodological review and future research opportunities

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Abstract

Purpose – Over the past decade, achieving sustainability in the transport sector has become a significant concern for governments and stakeholders. In this context, this study aims to comprehensively analyse the existing literature to document contributions and methodological deficiencies and pave the way for future research.

Design/methodology/approach – The authors used thematic, bibliometric and methodological systematic reviews of 39 articles across 30 sources from 112 authors between 2005 and 2023.

Findings – Using the Biblioshiny, the bibliometric analysis unveils the top prolific authors, contributing sources, most productive countries, top-cited papers and evolving keywords in advancing transport sustainability literature streams. The analyses revealed two strands of literature (those from the composite perspective and the triple-bottom-line perspective). The authors further consolidated indicators to measure the three pillars of transport sustainability comprehensively.

Originality/value – This paper uses a holistic approach to provide a state-of-the-art understanding of transport sustainability useful for the net zero or sustainable transport agenda. This paper is among the few attempts to consolidate indicators to measure transport sustainability from the triple bottom line perspective, whilst also offering exciting directions for future studies and inspiring hope for a more sustainable transport sector.

Keywords Transport sustainability, Sustainable development goals, Systematic literature review, Biblioshiny

Paper type Literature review

1. Introduction

The lifeblood of every economy is mobility, as it supports the holistic growth and well-being of individuals in society. Mobility is a wheel to move goods and services, offer employment access and improve people's livelihoods (Illahi and Mir, 2021a). In spite of the significance of mobility to the growth and well-being of any economy, sustaining it has become challenging for multiple reasons. One of the most crucial reasons could be traced to the



significant and increasing emissions the transport sector generates. According to the [World Bank \(2022\)](#), the sector is responsible for 23% of energy-related CO₂ emissions and 64% of topsoil consumption globally ([Afrouzi et al., 2023](#)). Additionally, the increasing loss of lives and properties because of traffic clashes remains a serious concern, particularly in developing economies. It is estimated that approximately 1.19 million people die because of road traffic crashes, and between 20 and 50 million sustain non-fatal injuries, with many suffering from disability ([World Health Organization, 2023](#)). Thus, regardless of the crucial role of the sector in national development, it will not be far from right to call transportation a necessary evil ([Illahi and Mir, 2021b](#)). This suggests that achieving sustainability in the transport sector is not a matter of choice but a prerequisite to sustaining the growth and well-being of economies and achieving the sustainable development goal (SDG₉).

The SDG₉ relates to achieving resilience in transport systems. Thus, the pillar targets industry, innovation and infrastructure. Specifically, Target 9.1 of SDG 9 aims to “develop quality, reliable, sustainable and resilient infrastructure, including regional and trans-border infrastructure, to support economic development and human well-being, focusing on affordable and equitable access for all”. The quest to achieve sustainable and resilient transport infrastructure requires an optimization of the transport sector to curb its damaging effects and exploit the progressive impacts ([Krishna, 2021](#)). Again, to achieve the net zero emissions target (a state where the amount of greenhouse gases released into the atmosphere is counterbalanced by the amount removed from the atmosphere, resulting in a net emissions level of zero) by the 2050 target, CO₂ emissions from the transport sector are expected to decrease ([Seddiek and Ammar, 2023](#)) by more than 3% yearly until 2030. These, coupled with other reasons, have sparked increasing transport sustainability discourse among the academic and industrial community ([Haghshenas and Vaziri, 2012](#); [Shiau and Liu, 2013](#); [Al-Atawi et al., 2016](#); [Ubaid and Shafi, 2021](#); [Allah and Mir, 2021](#); [Kumar and Anbanandam, 2022](#); [Hou et al., 2023](#); [Daimi and Rebai, 2023](#)). In spite of the growth of transport sustainability research in the past decade, views and appreciation, particularly the measurement of transport sustainability, remain divergent. Thus, the need to measure and understand transport sustainability using appropriate methodologies remains unaddressed ([Schaltegger et al., 2018](#); [Gyimah et al., 2023](#)). Extant literature has relied on the composite index to assess transport sustainability ([Hossein and Manouchehr, 2012](#); [Al-Atawi et al., 2016](#); [Ubaid and Shafi, 2021](#); [Xiaoran et al., 2023](#)), with limited focus on the individual dimensions (social, economic and environmental) of transport sustainability and what it constitutes.

To date, scholars are still divided regarding the accuracy of measures of transport sustainability. That notwithstanding, whether uni-dimensional or multi-dimension is used in measuring transport sustainability, the indicators or what constitutes transport sustainability must remain universal to guide policy directions. Unfortunately, different scholars rely on different indicators to assess the concept. Because the concept of transport sustainability is nascent and remains complex, it is imperative to conduct a review to synchronize the existing body of knowledge on the concept to direct future investigation and discourse. Prior reviews ([Sultana et al., 2019](#); [Karjalainen and Juhola, 2021](#)) have solely focused on urban transport sustainability; this study is, therefore, the first attempt to offer a state-of-the-art review using bibliometric and systematic review procedures to synchronize indicators, research themes, methodological choices and gaps in advancing SDGs from the perspective of transport sustainability.

This paper makes a three-fold contribution: First, it must emphasize that a systematic literature review on transport sustainability is rare, particularly in advancing sustainability scholarship using varying systematic review methodologies. This study, therefore,

contributes to filling the gap by drawing on 39 papers (from 30 sources from 112 authors) published by peer-reviewed journals indexed in Scopus between 2005 and 2023. The paper reviewed and synchronized indicators for measuring transport sustainability, offering a comprehensive understanding. This study offers one method for making sense of the growing knowledge of transport sustainability. It contributes to a critical systematic literature review (SLR) that enriches scholarly discussions, professional practice and governmental decision-making. Again, the study bridges the methodological gap by uncovering methodological choices in transport sustainability research. Second, using bibliometric and SLR analysis, the paper organizes scientific knowledge from different fields to generate new inquiries, research questions, themes, or trends. Thus, the study builds on past research by merging two methodologies (bibliometric and SLR) and using Biblioshiny software to explore fresh insights into transport literature to achieve the SDGs. Finally, transportation planners, the automobile industry and sustainability researchers can use the findings to address gaps in the literature and make methodological choices that advance sustainability scholarships. The findings are critical for driving SDG activities, research and innovation in modifying and strengthening methodological approaches and alternatives for achieving sustainability in the transportation sector.

The paper has the following structure. Section 2 discusses the procedure used in this study. Sections 3 and 4 present the outcomes of the bibliometric and systematic review analyses, respectively. Section 5 outlines the future research directions, while Section 6 concludes the study.

2. Methodology

2.1 Study approach

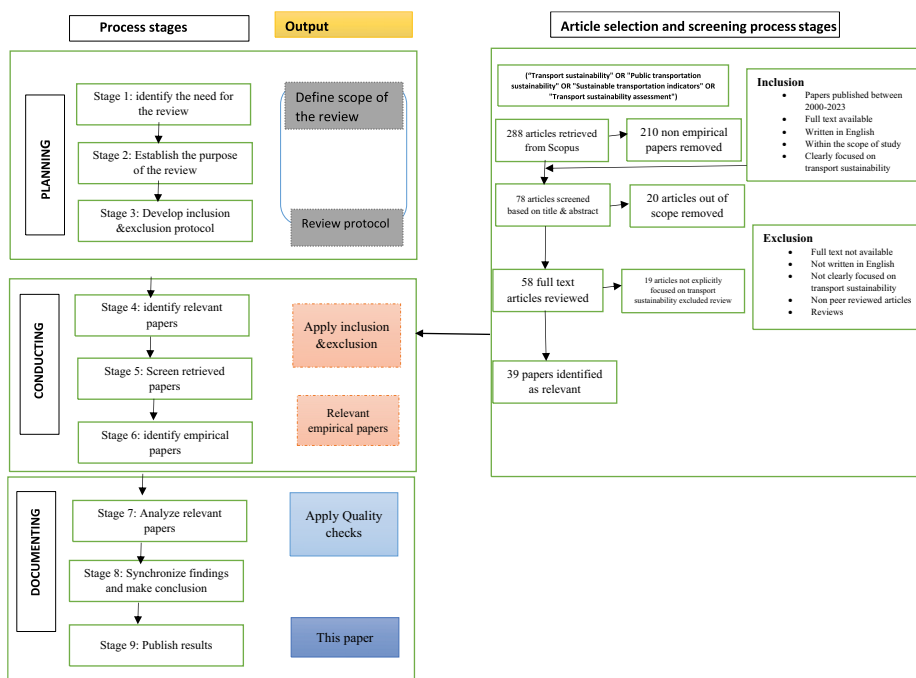
The paper combined SLR and bibliometrics to map contemporary practices to achieve the study's objective of using detailed content and topic technique (systematic qualitative review) and quantitative bibliometric tools (Pizzi *et al.*, 2020; Gyimah *et al.*, 2023). We collected data for the bibliometric analysis using the stages described by Mio *et al.* (2020). The first stage is the study's introduction (refer to Section 1.1), highlighting the purpose and objectives. The following section presents the review process, which identifies, chooses, assesses and synthesizes valid thematic subject matter. The last stage reports and discusses the study's descriptive results and theme topics.

2.2 Data

We collected the data for this paper by searching critical terms related to transport sustainability in the Scopus database. The choice of the Scopus database is justified because it is among the largest recognized databases for studies of this nature. We used the search Boolean string ("Transport sustainability" OR "Public transportation sustainability" OR "Sustainable transportation indicators" OR "Transport sustainability assessment") to generate the first set of data for the study (articles). The search resulted in 68 papers as of December 10, 2023, using the title of the papers, abstract and keywords.

2.3 Inclusion and exclusion criteria

To ensure the clarity and specificity of the review, well-defined exclusion and inclusion criteria were established. The study follows five stages to determine the final data or sample (see Figure 1). First, it focuses on papers from 2000 to 2023 using Appiah *et al.*'s (2022) search approach to retrieve quality papers from Scopus related to transport sustainability, resulting in 288 documents. Second, the search for social sciences, environmental science, engineering, energy, business, management and accounting studies is narrowed to English. It



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Figure 1. Process of systematic review in this study

reduces the papers to 108 to identify methodological choices and gaps in transport sustainability research from business, management, accounting perspectives, etc. Third, similar to [Sivarajah et al. \(2017\)](#) and [Mio et al. \(2020\)](#), the study excludes conferences, books, book series or chapters, trade publications, editorials, reviews and forthcoming articles, including only studies using cross-sectional, case study and longitudinal studies with a transport sustainability focus, resulting in 78 documents. Fourth, papers that do not consider any transport sustainability perspectives are excluded, narrowing the search to publications in the Scopus database that used empirical data and reducing the number of papers to 39. Thus, studies were included if they explored aspects of transport sustainability, such as transport sustainability measurement indicators, efficiency or sustainability, and if they delved into measuring transport sustainability. Finally, in stage 5, 39 papers were selected that aligned with the study's objectives or perspective.

2.4 Analysis strategy

Biblioshiny in *R Studio* software was used for the analysis. We conducted a descriptive analysis of top authors, contributing sources, productive countries, top-cited papers and keywords underlying transport sustainability. The study also performed traditional detailed content analysis of the 39 papers to identify unexplored research gaps and methodological choices or strategies to guide future studies.

3. Bibliometric analysis

3.1 Sample statistics

The results presented in [Table 1](#) comprised 39 papers between 2005 and 2023. The papers are spread across 30 sources from 112 authors and 146 authors' keywords, with an annual growth rate of 10.47% and a document average age of 5.72. The result indicates an increasing trend of approximately 11%, implying a slow growth pace of studies on transport sustainability. The table also shows 35.85 average citations a year per paper. The results in [Table 1](#) also revealed that out of the 112, just 2 (5.13%) were sole authors and 37 (94.87%) had multiple authorships, indicating high collaborations or team publications among scholars in the field. Moreover, the result indicated 3.18 co-authors per paper and 25.64% international co-authorships. Again, it is observed ([Figure 2](#)) that out of the 39 papers produced over the period, the highest production year was 2022 (7 papers), followed by 2023 (6 papers). In 2005 and 2010, only two articles were found. Thus, no papers were found from 2006 to 2009. In a decade (2011–2021), 24 papers were published. The number increased to seven papers in 2022 and six papers in 2023.

3.2 Countries' scientific production

[Table 2](#) presents the statistics of the countries per their number of publications. [Table 2](#) shows that China is the leading country with 26 papers. Iran follows with nine, and Brazil and Iran follow with five papers each. Tunisia, Turkey and the UK are followed by three papers each. Australia, France, Greece, Iraq, Poland, Portugal, Sweden and Uzbekistan had two papers each, and the remaining Canada, Denmark, Hungary, Italy, Lithuania, Nigeria, Saudi Arabia, Serbia, Singapore and the USA all had a paper. Again, the highest publications are from Asia, Europe and America, and a very minimal attempt has been made in other continents towards advancing transport sustainability literature. This also indicates avenues for collaborative studies in deprived regions such as Africa.

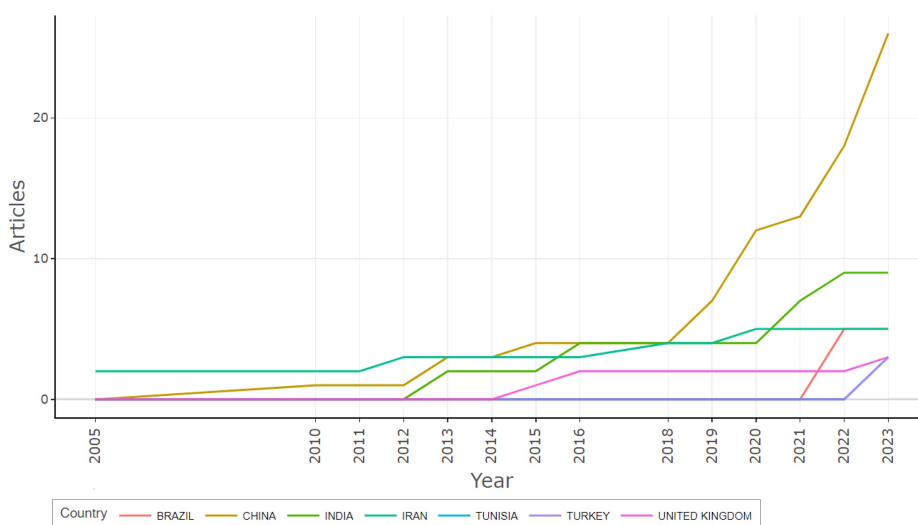
3.3 Most cited countries

[Table 3](#) presents the statistics of the top productive countries per their total citation and average citations. [Table 3](#) shows that China is the leading country, with 414 citations and an

Table 1. Sample statistics

Description	Results
Articles	39
Coverage	2005–2023
Sources	30
Annual growth rate (%)	10.47
Document average age	5.72
Average citations per doc	35.85
Keywords plus (ID)	329
Author's keywords (DE)	146
Authors	112
Authors of single-authored docs	2
Single-authored docs	2
Co-authors per doc	3.18
International co-authorships %	25.64

Source: Authors' own creation



Source: Authors' own creation

Figure 2. Countries' production over time

average citation of 34.5. Iran and India also follow with 323 (107.7) and 198 (28.3), respectively. Australia follows with 133 (66.5), Greece and Italy, 79, Hungary, 47, Serbia, 16 and the UK with 15 average citations. Asia and Europe dominate both total citation, average and region. Unlike Asia, Europe and Australia, no other continent is among the top 10 countries advancing transport sustainability literature. This suggests avenues for collaborative studies in deprived regions such as Africa.

3.4 Author's keywords (most frequent words)

Authors' keyword analysis aids in evaluating the prevailing trends in research to highlight gaps or stimulate future research opportunities for discussion. Figure 3 shows the top ten keywords used in transport sustainability. Figure 3 shows sustainable development, sustainability and transport systems. However, essential keywords, including urban transport, decision-making, sustainable transport, data envelopment analysis (DEA) and transportation planning, are pertinent trends in transport sustainability. Figure 4 (Treemap) also presents 20 keywords in advancing transport sustainability discourse. Adding to those in Figure 3, other keywords that transport sustainability scholars use include analytical hierarchy process, factor analysis, principal component analysis, environmental impact, fuzzy mathematical, carbon dioxide, hierarchical systems, energy utilization, index method and indicator system.

3.5 Top five contributing journals

Table 4 shows the top five contributing journals in transport sustainability. *Ecological Indicators* is the top contributing journal in transport sustainability, with five papers, followed by the *International Journal of Sustainable Transportation* and *Transportation Research Part D: Transport and Environment*, with three papers each and, lastly, the *Journal of Cleaner Production*, with two papers.

Table 2. Countries’ scientific production

Country	Freq	%	Region
China	26	32.5	Asia
India	9	11.25	Asia
Brazil	5	6.25	America
Iran	5	6.25	Asia
Tunisia	3	3.75	Africa
Turkey	3	3.75	Asia
UK	3	3.75	Europe
Australia	2	2.5	Australia
France	2	2.5	Europe
Greece	2	2.5	Europe
Iraq	2	2.5	Asia
Poland	2	2.5	Europe
Portugal	2	2.5	Europe
Sweden	2	2.5	Europe
Uzbekistan	2	2.5	Asia
Canada	1	1.25	America
Denmark	1	1.25	Europe
Hungary	1	1.25	Europe
Italy	1	1.25	Europe
Lithuania	1	1.25	Europe
Nigeria	1	1.25	Africa
Saudi Arabia	1	1.25	Asia
Serbia	1	1.25	Europe
Singapore	1	1.25	Asia
USA	1	1.25	America
Total	80	100	

Source: Authors’ own creation

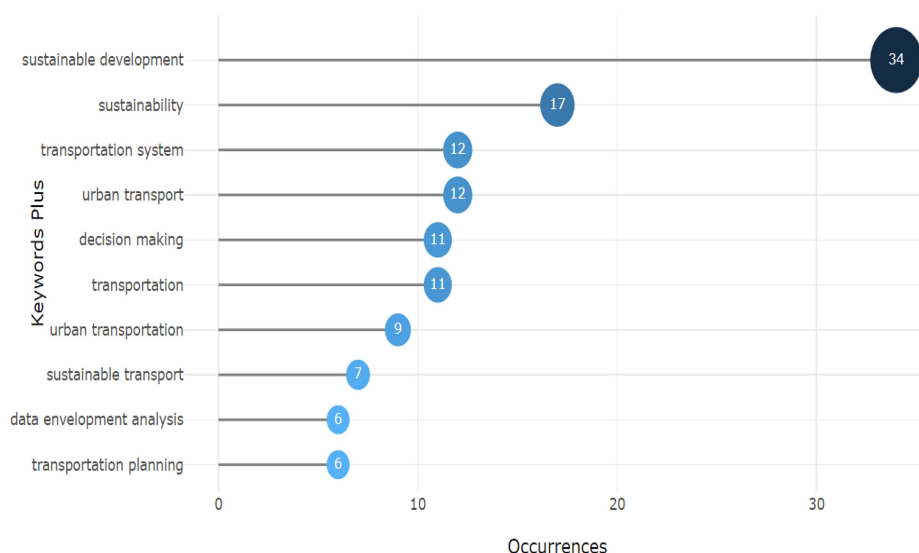
Table 3. Most cited countries

Country	TC	Average article citations	Region
China	414	34.5	Asia
Iran	323	107.7	Asia
India	198	28.3	Asia
Australia	133	66.5	Australia
Greece	79	79	Europe
Italy	71	71	Europe
Hungary	47	47	Europe
Serbia	16	16	Europe
United Kingdom	15	15	Europe

Source: Authors’ own creation

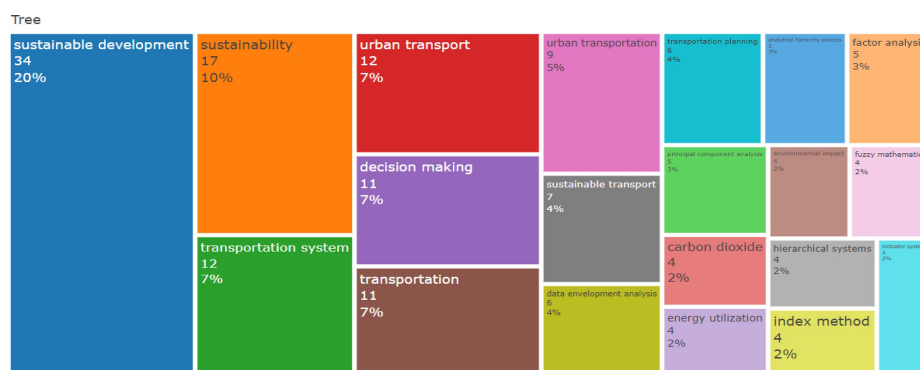
3.6 Top contributing authors

[Table 5](#) shows that Illahi and MIR of the National Institute of Technology Srinagar in India are the most relevant authors, with four papers. [Table 5](#) further shows Shiau with two papers and Vaziri, Li, Rajabifard and Reisi with two papers.



Source: Authors' own creation

Figure 3. Most frequent words



Source: Authors' own creation

Figure 4. Tree map

4. Methodological choices

The paper also examined the methodologies used by previous studies on transport sustainability via traditional in-depth content analysis of the 39 papers extracted. The methodological choice analysis aided in exploring underexplored methodologies to guide future research directions (Gyimah *et al.*, 2023). The section discussed the choice of

Table 4. Top 5 contributing journals

Journals	No.	%
<i>Ecological Indicators</i>	5	13
<i>International Journal of Sustainable Transportation</i>	3	8
<i>Transportation Research Part D: Transport and Environment</i>	3	8
<i>Energies</i>	2	5
<i>Journal of Cleaner Production</i>	2	5

Source: Authors' own creation

Table 5. Top contributing authors

Authors	Articles	%	Articles fractionalized	Ranking
Illahi U	4	3.57	2.00	1st
Mir MS	4	3.57	2.00	1st
Shiau TA	3	2.68	1.33	3rd
Vaziri M	2	1.79	1.00	4th
Li Y	2	1.79	0.38	5th
Rajabifard A	2	1.79	0.38	5th
Reisi M	2	1.79	0.38	5th

Source: Authors' own creation

methodologies, including the research design, data type, analytical method and measurement of transport sustainability.

4.1 Research design

The result, presented in Table 6 below, shows that most transport sustainability studies used a qualitative approach ($n = 9$, 21.1%), while 30 (76.9%) used a quantitative approach. It is, therefore, evident that most transport sustainability relies on a qualitative approach. Similarly, the majority ($n = 18$, 64.3%) used primary data, and the remaining ($n = 10$, 35.7%) used secondary data.

4.2 Analytical method

The content analysis revealed that both qualitative and quantitative analysis methods were used. The result highlights 11 different qualitative analytical methods and 3 quantitative analytical methods. Subsequent sections present the various analytical methods that were used.

4.3 Qualitative, content and thematic analysis

Using the content analysis, codes were generated for the different qualitative techniques, and a descriptive method was used to analyse the methods used. Based on the review of the 38 papers, 11 different qualitative analytical methods were used, specifically, $n = 9$ (21.4%) used analytic hierarchy process (AHP), $n = 4$ (9.5%) used multi-criteria analysis, $n = 3$ (7.1%) used fuzzy and $n = 2$ (4.8%) used equal waiting, rough set theory and improved support vector partition algorithm with variable fuzzy set method (ISPA-VFSM), respectively. Others, such as ANP, concordance analysis, fuzzy cognitive maps, hybrid

Table 6. Methodological choices

Approach	Category	Frequency	%
<i>Data type</i>	Quantitative	9	23.08
	Qualitative	30	76.92
<i>Analytical methods</i>	Secondary	10	35.71
	Primary	18	64.29
	AHP	9	21.43
	Fuzzy	3	7.14
	DEA	8	19.05
	PCA	7	16.67
	Equal weighting	2	4.76
	Analytic network process	1	2.38
	ISPA-VFSM	2	4.76
	MCA	4	9.52
	Concordance analysis	1	2.38
	Rough set theory (RST)	2	4.76
	Fuzzy cognitive maps	1	2.38
	Hierarchical Bayesian network model (BNM)	1	2.38
	RTI	1	2.38

Source: Authors' own creation

bayesian network model and robust trend identification, appeared once ($n = 1$, 2.4%). The findings indicate that contemporary transport sustainability scholars (Tzay-An *et al.*, 2013; Rajak *et al.*, 2016; Allah and Mir, 2021; Kumar and Anbanandam, 2022; Hou *et al.*, 2023; Daimi and Rebai, 2023) have heavily relied on qualitative analytical methods to develop measures and evaluate transport sustainability performance in the past decade in the quest to achieve the SDGs before 2030.

4.4 Data envelopment analysis

DEA is a contemporary analytics technique that aids in measuring relative efficiency. DEA has the potency of establishing the interplay between multiple inputs and outputs more robustly than traditional ratio analysis (Barnett *et al.*, 2005). The content analysis revealed that seven papers used DEA. Tian *et al.* (2020) used slack-based measure-DEA to measure regional transport sustainability in China. They discovered that Shaanxi's transport sustainability over half of the years is inefficient, and the main reason is that the efficiency of environmental and social dimensions is low. Similarly, Stefaniec *et al.* (2020) also used DEA to undertake a sustainability assessment of inland transportation in China. They opined that social sustainability has been the weakest component of inland transport since 2012. DEA was also used in the study of Mo and Wang (2019), which examined the environmental sustainability of road transport in OECD countries and discovered that OECD countries have improved their overall managerial disposability performance from 2000 to 2014 as a result of technological progress and tightening regulations on fuel economy and vehicle emissions. Finally, Shiau and Jhang (2010) combined DEA and RST to measure transport sustainability. They concluded that if the "cost efficiency" or "service reduction" indicator performs well, the transport system will move towards more sustainable development.

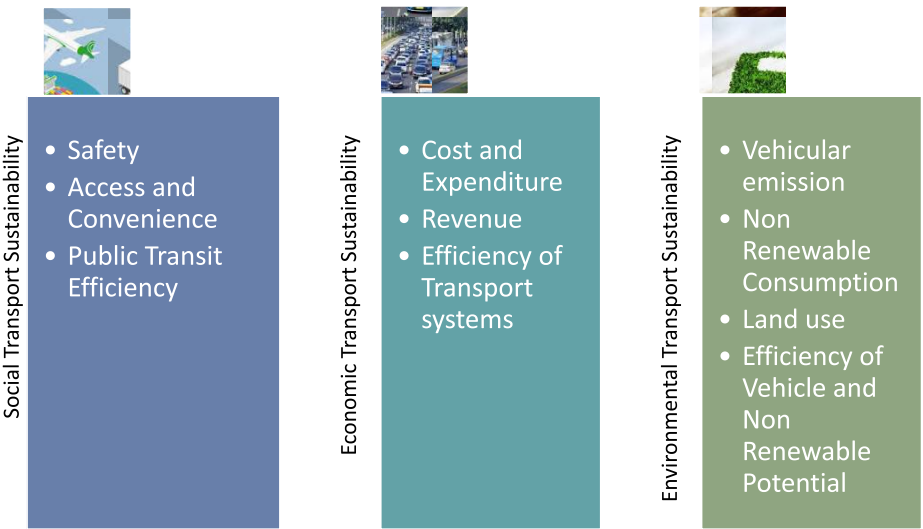
4.5 Principal component analysis

Principal component analysis (PCA) is a dimensionality reduction method often used to reduce the dimensionality of large data sets by transforming a large set of variables into a smaller one that still contains most of the information in the large set. Previous studies have also used PCA to develop an index for transport sustainability. The content analysis revealed eight papers that used PCA – [Reisi et al. \(2014\)](#) to compute the transport sustainability index in Melbourne. The study found nine transport sustainability indicators relevant to urban transport that deal with environmental, social and economic aspects. The indicators were integrated into environmental, social and economic sub-indices and a composite index.

5. Thematic analysis

5.1 Transport sustainability thematic analysis

Drawing on the triple-bottom-line framework, we thematically analysed the 39 papers to understand how previous studies have approached or measured transport sustainability. The analysis aids in identifying the relevant indicators and coupling themes to aid further discourse or a detailed understanding of transport sustainability. The study found two essential strands of studies from the content analysis. While the first strand measured transport sustainability by a composite index, the other strand focused on individual dimensions (social, economic and environmental) (see [Figure 5](#)). Our analysis revealed that the majority of the studies relied on the composite index as a measurement for transport sustainability (Hosseini and Manouchehr, 2012; [Al-Atawi et al., 2016](#); Ubaid et al., 2020; Xiaoran et al., 2023). Others also used the individual dimensions (social, economic and environmental), and we have conducted a more profound analysis to harmonize the indicators used in measuring the various individual dimensions (social, economic and environmental) and to create opportunities for future investigations.



Source: Authors' own creation

Figure 5. Transport sustainability strands

5.2 Environmental transport sustainability

Environmental transport sustainability (ETS) appeared to be the most discussed perspective of transport sustainability in literature, with a very high focus on carbon emissions. Our analysis revealed that ETS could be approached from four critical perspectives: vehicular emissions, non-renewable energy consumption by transportation, land use in transportation infrastructure, environmental efficiency of vehicles and renewable energy potential (Illahi and Mir, 2021b). A total of 51 indicators were identified for the environmental sustainability pillar of transport sustainability. As shown in Appendix 1, 14 items were identified for vehicular emissions, 11 for non-renewable energy conception, 20 for land use and 6 for vehicle and renewable energy potential.

5.3 Social transport sustainability

Social transport sustainability (STS) appeared to be the least discussed perspective of transport sustainability in the literature. Our analysis revealed that STS could be approached from three critical perspectives: safety, access and convenience and public transit efficiency. The study identified 42 indicators for STS. Specifically, 24 indicators were identified for safety, 13 for access and convenience and 5 for public transit efficiency (see Appendix 1).

5.4 Economic transport sustainability

Economic transport sustainability (ECTS) also appeared in the literature as a perspective of transport sustainability. Our analysis revealed that ECTS could also be approached from three critical perspectives: cost and expenditure, revenue and efficiency. The study identified 30 indicators for ECTS. Specifically, 18 indicators were identified for cost and expenditure, 5 for revenue and 7 for efficiency (see Appendix 1).

6. Discussion and future research agenda

6.1 Contextual gap and future research direction

The review indicated that most publications on advancing transport sustainability were conducted in Asia, Europe and America, with minimal attempts made in other continents, such as Africa. Over the period reviewed, only two transport sustainability studies were found on the continent. Africa is among the continents that are challenged to achieve the SDGs. In spite of different interventions, it is unclear how the SDGs could be achieved by 2030. The wheel of every economy is mobility, as it facilitates growth and well-being. Unfortunately, sustaining mobility remains a great challenge as it comes among the significant and growing emission generators globally, and Africa is no exception. Again, the African continent is characterized by vast losses of resources, both in terms of human lives and economic losses because of traffic crashes. Therefore, it is imperative to see transport sustainability as a non-negotiable agenda. Additionally, per the 2030 Agenda, achieving resilience in transportation systems is one of the top priorities for the SDGs. To better formulate policies to ensure transport sustainability and the achievement of the SDGs, we encourage scholars to investigate the barriers to averting transport sustainability, a crucial aspect of SDGs 2, 7, 9, 11 and 12. Furthermore, we do not just encourage replication of previous studies in other contexts but rather the need for future studies to understand the unique institutional forces in the African context, including culture, regulations, governance and policy machinery related to advancing transport sustainability. We also encourage scholars to investigate sustainable transport solutions and the roles of institutions in advancing transport sustainability. It is also imperative for future studies to expand research towards sustainable transport solutions such as electric vehicles, autonomous vehicles,

ridesharing, MaaS, etc. and how they have contributed to transport sustainability in Africa and even beyond.

6.2 Methodological gap and future research direction

The review also found gaps in the application of contemporary methodologies. Our review showed earlier studies focused on primary data using AHP to validate transport sustainability indicators. Considering the limitations or weaknesses in using cross-sectional data, we recommend that future studies use longitudinal methods in future transport sustainability studies. Similarly, the study noted a methodological gap with the application of econometric models (i.e. ordinary least squares, least squares, generalized method of moments, system generalized method of moments (S-GMM), Granger causality, etc.), efficiency models (DEA, etc.), data mining and machine learning algorithms to enhance transport sustainability research. We, therefore, call for future studies to use econometric models (i.e. ordinary least squares, least squares, generalized method of moments, S-GMM, Granger causality, etc.), efficiency models (DEA, etc.), data mining and machine learning algorithms to offer deeper insights and contributions towards transport sustainability research and the SDG targets. Earlier techniques used cannot address endogeneity problems, which could result in spurious results. Future research can also use predictive regression models such as structural equation models (SEMs), multinomial logistic regression, structural breaking models, threshold analysis, lasso, ridge or Bayesian linear regression to better understand the interconnected linkages between transport sustainability and its drivers. We urge researchers to use nonlinear regression, such as polynomial and quintile models, to examine non-monotonic connections.

Another issue noted in our review is the measurement differences in transport sustainability studies. Specifically, we identified three critical issues in terms of measuring transport sustainability:

- (1) over-dependence on the composite index;
- (2) focus on limited pillars (i.e. environment and economics); and
- (3) varying measuring indicators.

To overcome these problems, we have consolidated indicators (see [Appendix 1](#)) to comprehensively measure the three pillars of transport sustainability. We, therefore, encourage future studies to use longitudinal data to validate these indicators. Studies that can validate these indicators across a wide range of countries could offer crucial methodological contributions to transport sustainability literature. Additionally, we recommend future studies to individually investigate the pillars of transport sustainability to offer a comprehensive assessment of efforts and policy interventions.

6.3 Policy, intervention gap and future research direction

Green technologies have been cited as a critical mitigation for carbon emissions. Governments and significant stakeholders continue to make strides in green technological investments. It is expected that while the proliferation of green technologies increases, countries will make significant progress towards achieving the SDG targets, particularly in transport sustainability. It remains unclear how these efforts through education, incentives, investment in sustainable transport policies, acceleration of electric vehicles, etc. contribute to sustainability in the transport sector. We recommended future studies to investigate the spillover effects of the government's efforts through education, incentives, investment in sustainable transport policies and acceleration of electric and autonomous vehicles on sustainability in the transport sector.

Again, many countries (Argentina, Canada, Chile, China, Colombia, Denmark, the European Union (27 countries), Japan, Kazakhstan, Korea, Mexico, New Zealand, Norway, Singapore and many others) have implemented emission taxes, with many other countries also at the preparatory stages of implementation. While it was expected that emission taxes could contribute to a 21.5% global greenhouse gas emissions decrease in 2021, it is still unclear how these policies have successfully facilitated sustainability, particularly in the transport sector (Silajdzic and Mehic, 2018; Zhou *et al.*, 2018; Andersson, 2019; Hussain *et al.*, 2023). We therefore invite scholars to provide answers to these burning questions:

- RQ1. Has implementing carbon or emission taxes significantly contributed to transport sustainability?
- RQ2. Are there any differences in transport sustainability performance between countries that have implemented carbon or emission taxes and those that have yet to?
- RQ3. Are there spatial differences in the spillover effects of green technologies?

Moreover, in spite of the growth of stakeholder investment through loans, grants and government budgetary allocation to the transport sector, it is unknown how these investments have contributed to transport sustainability, particularly in developing economies. It is also recommended that future studies use efficiency techniques such as DEA to evaluate the efficiency of such investments in the transport sector. Future studies could also investigate how environmental regulations, foreign direct investment, investment in pollution control and innovation compensation could drive transport sustainability. Finally, the acceleration of sustainable mobility in Africa and many developing countries is low in spite of policies and interventions implemented over the years. Therefore, we call on future studies to explore the underlying factors affecting the spread of sustainable mobility solutions in developing countries, mainly African countries.

7. Conclusion

The growth of transport sustainability literature after the launch of the SDGs in 2015 has seen some remarkable growth, though insufficient. Surprisingly, the earlier discourse has dominantly focused on policy-making at the expense of scholarly perspective. This makes it challenging to adequately diagnose the situation, develop befitting policies for the sustainability of the transport sector and advance the SDGs globally. In this light, we conducted a comprehensive review to document transport sustainability-related studies related to the SDG targets. Our review used a thematic, bibliometric and methodological systematic review of 39 articles across 30 sources from 112 authors between 2005 and 2023. Using the *Biblioshiny*, our bibliometric analysis unveils the top prolific authors, contributing sources, most productive countries, top-cited papers and evolving keywords in advancing transport sustainability literature streams. We also performed thematic analysis to identify major thematic patterns in the underlying pillars of transport sustainability literature for theory and practice. Additionally, to the best of the authors' knowledge, this study is the first to conduct a traditional detailed content analysis to identify methodological choices and gaps in transport sustainability literature. Further, our study is the first to conduct bibliometric and SLR globally. The bibliometric analysis shows that transport sustainability literature is still an embryonic study area that contributes to more excellent prospects for the future scope of studies because of the sudden upsurge in publications. Also notwithstanding, our results indicate that the most productive authors and countries are from Asia, Europe and America, indicating that there is scant substantial input in transport sustainability literature from the African perspective. Thus, there is an urgent need for scholars

from African nations and developing countries to contribute to the underlying stream of literature. Thematic analysis revealed two main strands of literature. While the first strand measured transport sustainability by a composite index, the other strand focused on individual dimensions (social, economic and environmental). Based on the detailed content analysis of these strands of papers, we have consolidated indicators to comprehensively measure the three pillars of transport sustainability (see [Appendix 1](#)). Additionally, the content methodology review suggests the use of other quantitative analytical tools or models such as econometric models (i.e. ordinary least squares, generalized method of moments, S-GMM, Granger causality, etc.), efficiency models (DEA *et al.*, etc.), data mining, machine learning algorithms and predictive regression (SEMs), multinomial logistic regression, structural breaking models, threshold analysis, lasso, ridge, or Bayesian linear regression) to offer deeper insights and contributions towards transport sustainability research and the SDG targets. This paper constitutes the first global bibliometric and systematic literature review on transport sustainability; the study reveals the embryonic nature of this field and the promising prospects for future studies, particularly underscoring the urgent need for increased contributions from African nations and developing countries to address regional gaps and advance the SDGs.

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Further reading

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Appendix 1. transport sustainability indicators

Social dimension

Safety of transport users

- Total road traffic crashes (RRTC's) per capita.
- Total RRTC's per vehicle kilometres travelled.
- Total RRTC's per total length of roads.
- Total RRTC's per total number of vehicles.
- Total RRTC's per total number of drivers with valid license.
- Total road traffic fatalities (RRTF's) per capita.
- Total RRTF's per vehicle kilometres travelled (VKT).
- Total RRTF's per total length of roads.
- Total RRTF's per total number of vehicles.
- Total RRTF's per total number of drivers with valid license.
- Total serious injuries (RSI) in road traffic per capita.
- Total RSIs in road traffic per an. VKT.
- Total RSIs in road traffic per total length of roads.
- Total RSIs in road traffic per total number of vehicles.
- Total RSIs in road traffic per total number of drivers with valid license.
- Total minor injuries (RMI's) in road traffic per capita.

Total RMIs in road traffic per an. VKT.
Total RMIs in road traffic per total length of roads.
Total RMIs in road traffic per total number of vehicles.
Total RMIs in road traffic per total number of drivers with valid license.
Total non-motorized traffic fatalities per total recorded RTFs.
Total public transportation fatalities per total number of buses.
Total accident cases in railways per total length of railway track.
Total fatalities in railways per total length of railway track.

Access to transport modes and conveniences.

Total number of registered vehicles per capita.
Total number of registered vehicles per total number of drivers with valid driving license.
Total number of registered vehicles per total number of households.
Total number of fuel filling stations per total length of roads.
Total inter-state work trips per capita.
Total inter-state work trips per area.
Total domestic tourist visits per capita.
Total domestic tourist visits per area.
Total length of railway roads per total length of running railway track.
Total number of passenger trips by scheduled flight operations per capita.
Total number of passenger trips by scheduled flight operations per area.
Total number of passenger trips by scheduled flight operations per total number of households.

Public transit efficacy

Performance of State Road Transport Undertakings (SRTUs) staff/bus ratio.
Percentage of SRTUs occupancy ratio.
Passengers carried by SRTUs per bus per day.
SRTUs passenger kilometres offered.
SRTUs passenger kilometres performed.

Environment dimension

Vehicular emissions. Carbon emissions for transportation
Cost of air pollution emissions
Cost of traffic noise pollution
Depletion of non-renewable resources
GHG emissions (CO₂-e)
Other air pollutants (CO, NO₂, PM10)
Land consumption for transport
GHG emissions by transportation per capita
GHG emissions by transportation per area
GHG emissions by transportation per total energy consumption of major petroleum products by transportation
GHG emissions by transportation per total vehicle kilometres travelled (VKT)
Average density of PM10 in µg/m³
Average density of SO₂ in µg/m³
Average density of NO₂ in µg/m³

Non-renewable energy consumption by transportation

Energy consumption of significant petroleum products by transportation per capita
An. energy consumption of major petroleum products by transportation per area
An. energy consumption of major petroleum products by transportation per an. VKT
Percent consumption of diesel fuel in the transportation sector
An. energy consumption of significant petroleum products by transportation per gross state domestic product (GSDP)
An. energy consumption of major petroleum products by transportation per total number of vehicles
Percent length of railway routes electrified per total length of railway routes
Percentage of an. consumption of diesel by public transportation modes
Percentage of an. consumption of diesel by private transportation modes
Percentage of an. consumption of petrol by public transportation modes, including shared taxis and three-wheelers
Percentage of an. consumption of petrol by private transportation modes, including cars and two-wheelers

Land use in transportation infrastructure

Total length of roads per capita
The total length of roads per area
The total length of roads per an. VKT
Percentage of total length of NHs per total length of roads
Total length of national highways (NHs) per capita
Total length of NHs per area
The total length of NHs per an. VKT
Percentage of total length of state highways (SHs) per total length of roads
Total length of SHs per capita
Total length of SHs per area
The total length of SHs per an. VKT
Percentage of total length of urban roads per total length of roads
Total length of urban roads per capita
Total length of urban roads per area
The total length of urban roads per an. VKT
Percentage of total length of other Public Works Department (PWD) roads per total length of roads
Total length of other PWD roads per capita
Total length of other PWD roads per area
The total length of other PWD roads per an. VKT
Percentage of total length of rural roads per total length of roads
Total length of rural roads per capita

Environmental efficiency of vehicles and renewable energy potential

Percentage of compressed natural gas (CNG) filling stations to petrol filling stations
An. renewable energy potential per capita
An. renewable energy potential per total number of vehicles
An. renewable energy potential per an. VKT
An. renewable energy potential per an. energy consumption of significant petroleum products by transportation

SRTUs fuel efficiency (km per liter of high-speed diesel/km per kg of CNG)

Economic dimension

- Transport costs and expenses.* An. SRTU expenditure per capita
- An. SRTUs expenditure per GSDP
- An. SRTUs expenditure per GSDP per capita
- Funds allocated under economic importance and inter-state connectivity per capita
- Funds allocated under economic importance and inter-state connectivity per GSDP
- Funds allocated under economic importance and inter-state connectivity per GSDP per capita
- Funds released under economic importance and inter-state connectivity per capita
- Funds released under economic importance and inter-state connectivity per GSDP
- Funds released under economic importance and inter-state connectivity per GSDP per capita
- An. accrual allocation of funds under Central Road Fund (CRF) schemes per capita
- An. accrual allocation of funds under CRF schemes per GSDP
- An. accrual allocation of funds under CRF schemes per GSDP per capita
- An. accrual release of funds under CRF schemes per capita
- An. accrual release of funds under CRF schemes per GSDP
- An. accrual release of funds under CRF schemes per GSDP per capita
- Allocation for repair and maintenance of NHs per total length of NHs

Revenue generated from transport

- An. SRTUs revenue per capita
- An. SRTUs revenue per GSDP
- An. SRTUs revenue per GSDP per capita
- Revenue from the rate of taxes levied on petrol
- Revenue from the rate of taxes levied on diesel

Economic efficiency of transportation system

- Percentage of SRTU fleet utilization
- SRTUs staff productivity measured in km per staff per day
- SRTU vehicle productivity measured in km per bus per day
- An. freight shipment at airports per capita
- An. freight shipment at airports per area
- Freight train kilometres performed per capita
- Freight train kilometres performed per area

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